Radiation Physics Note #73

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# SOME CHARACTERISTICS OF THE RADIATION FIELD OVER THE PBAR TARGET VAULT

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## Introduction

The shielding above the PBAR target vault is shown schematically in Figs. 1 and 2. It consists basically of six feet of steel followed by neutron covers of polyethylene beads and borax. The top area is surrounded by concrete blocks and access is limited by a locked gate under RSO control. Some of the characteristics of the prompt radiation field in this region arising from beam interactions in the target and lithium lens are described in this note.

## Quality Factor

During routine operation at 120 GeV a recombination chamber[1] was used to determine the quality factor of the radiation in the area above the vault. The charge accumulated at the anode at voltages between -20V and -1200V was normalized to the response of a tissue equivalent ion chamber

(Chipmunk) placed adjacent to it to compensate for any variance in flux at each measurement. The experimental arrangement is depicted in figures 1&2.

The normalized response is plotted as a function of applied voltage in Fig. 3. A least squares fit to $R=kV^n$ (the expected response function of the chamber as a function of voltage[2]) gives a value of n=0.0231. Based on the results of TM 1248[3], a power law relation then predicts a QF of 1.23 and a linear relation a value of 0.97. It is noted, therefore, that the neutron component to the total radiation field must be small, and does not contribute much to the dose. The polyethylene bead and borax shield appears to be quite effective in reducing the expected approximately 1-MeV neutrons that leak through the thick steel shielding.

<u>Absorbed Dose and Dose attenuation</u>

A second somewhat qualitative, measurement was conducted to observe the effectiveness of the neutron shield. A unistrut support was fastened to the bottom of the first (upstream) neutron cover over the PBAR vault approximately six inches from the downstream edge. Attached to this was a tissue equivalent ion chamber (Scarecrow) and a Fermilab designed neutron dectector[4] (Albatross). The active portion of each detector was suspended approximately 15" below the bottom of the shield. Immediately above them and resting on the top of the shield were placed another Scarecrow and Albatross (figures 1&2).

The targeting energy was 120 GeV incident protons at an intensity of ~$1.1x10^{12}$p/pulse. Several integrations were made for the length of a Tev super cycle (120 seconds at the time of the measurements). This cycle consisted of 33 target pulses separated in groups of eleven at a three second frequency with 10 seconds between each group.

The integrated outputs of the tissue equivalent ion chambers were scaled; similarly, the Albatross outputs were scaled. The ratios of background corrected values for the below-shield to the above-shield detectors is listed in table 1.

**Table 1**

| | run1 | run2 | run3 | run4 | average | |
|---|---|---|---|---|---|---|
| Albatross/Albatross<br>below above | 282 | 228 | 278 | 264 | 268 | $\pm 28$ |
| Scarecrow/Scarecrow<br>below above | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | |

As seen from the Albatross results, the shield of polyethlene beads and borax is effective for removing neutrons; it appatently attenuates the neutron dose by a large factor. Unfortunately the actual neutron attenuation factor is uncertain because the Albatross, due to the manner in which it is calibrated, does not only respond to neutrons but to photons as well. The overall tissue equivalent absorbed dose attenuation of the shield as measured by the Scarecrow is 19.0. Because the recombination chamber could not be utilized in high radiation fields it was not possible to measure the quality factor beneath the shield, so that the dose-equivalent attenuation could not be obtained.

A measurement was conducted to observe the distribution of the absorbed dose as a function of the Z direction of the beam in the area above the vault. Both a tissue equivalent ion chamber (Chipmunk) and an Albatross where placed above the shielding along the beam line starting at the upstream end of the shielded vault area. Several measurements were made at various points along the Z axis (beam direction). Figure 4 is a graphic representation of the measured dose rates.

## REFERENCES


1) REM-2 Chamber, ZZUJ "Polon"- Radiation Dosimetry Instrument Division, Bydgoszcz, Poland.

2) Sullivan A.H. and Barrli J., "An Ionization Chamber for the Estimation of the Biological Effectiveness of Radiation", CERN Report No. 63-17 (European Organiztion for Nuclear Research, Geneva, 1963).

3) Cossairt J.D., Grobe D.W. and Gerardi M.A. 1984, Measurements of Radiation Quality Factors Using a Recombination Chamber, Fermi National Accelerator Laboratory, Batavia, Il 60510, TM-1248.

4) Awschalom M., Borak T. and Howe H., 1971, A Study of Spherical, Pseudospherical and Cylindrical Moderators for a Neutron Dose Equivalent Rate Meter, Fermi National Accelerator Laboratory, Batavia, Il 60510, TM-291.

## FIGURES

1) Plan view of recombination chamber, ion chamber and Albatross for quality factor and shielding effectiveness measurements.

2) Horizontal view of recombination chamber, ion chamber and Albatross for quality factor and shielding effectiveness measurements.

3) Plot of recombination chamber response as a function of voltage.

4) Representation in Z for distribution of measured absorbed dose.

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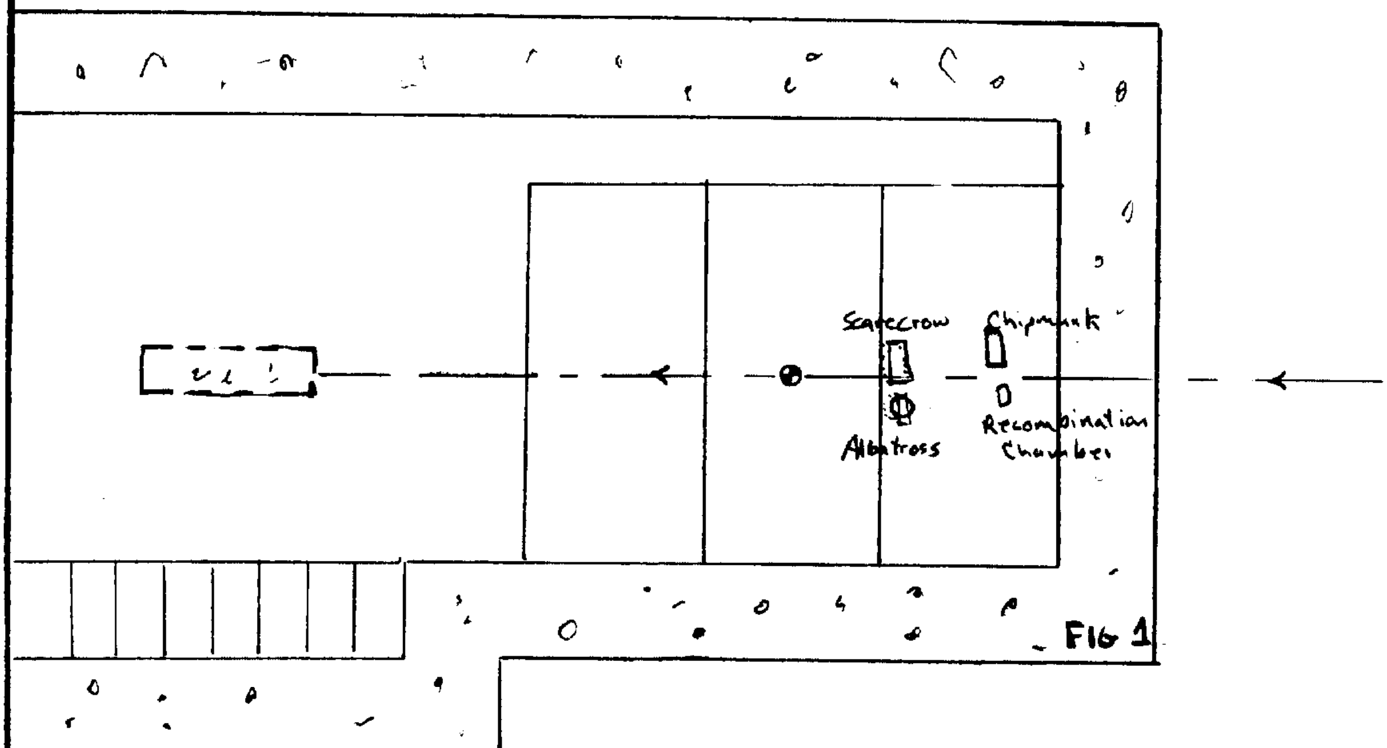



FIG 1

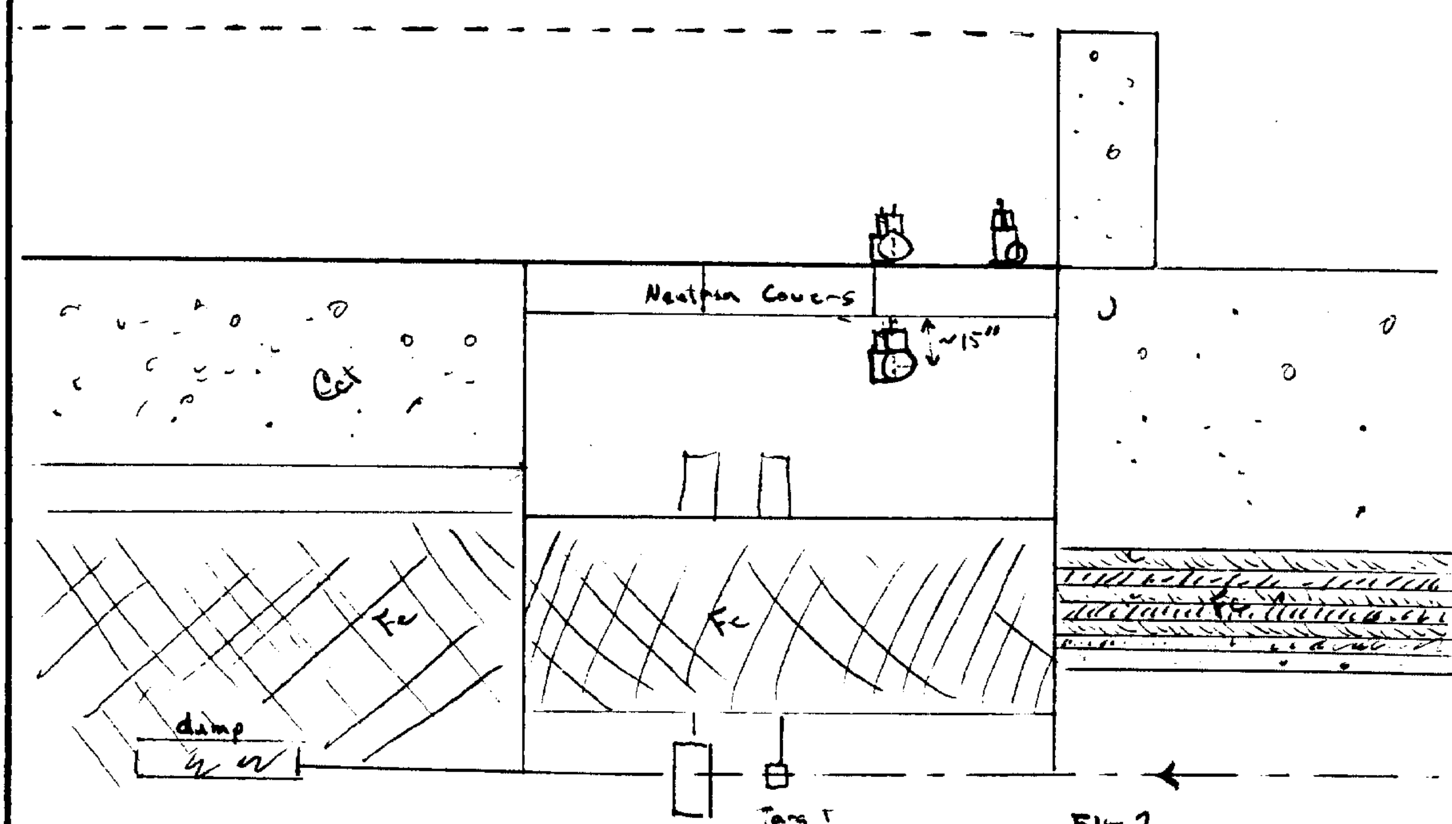
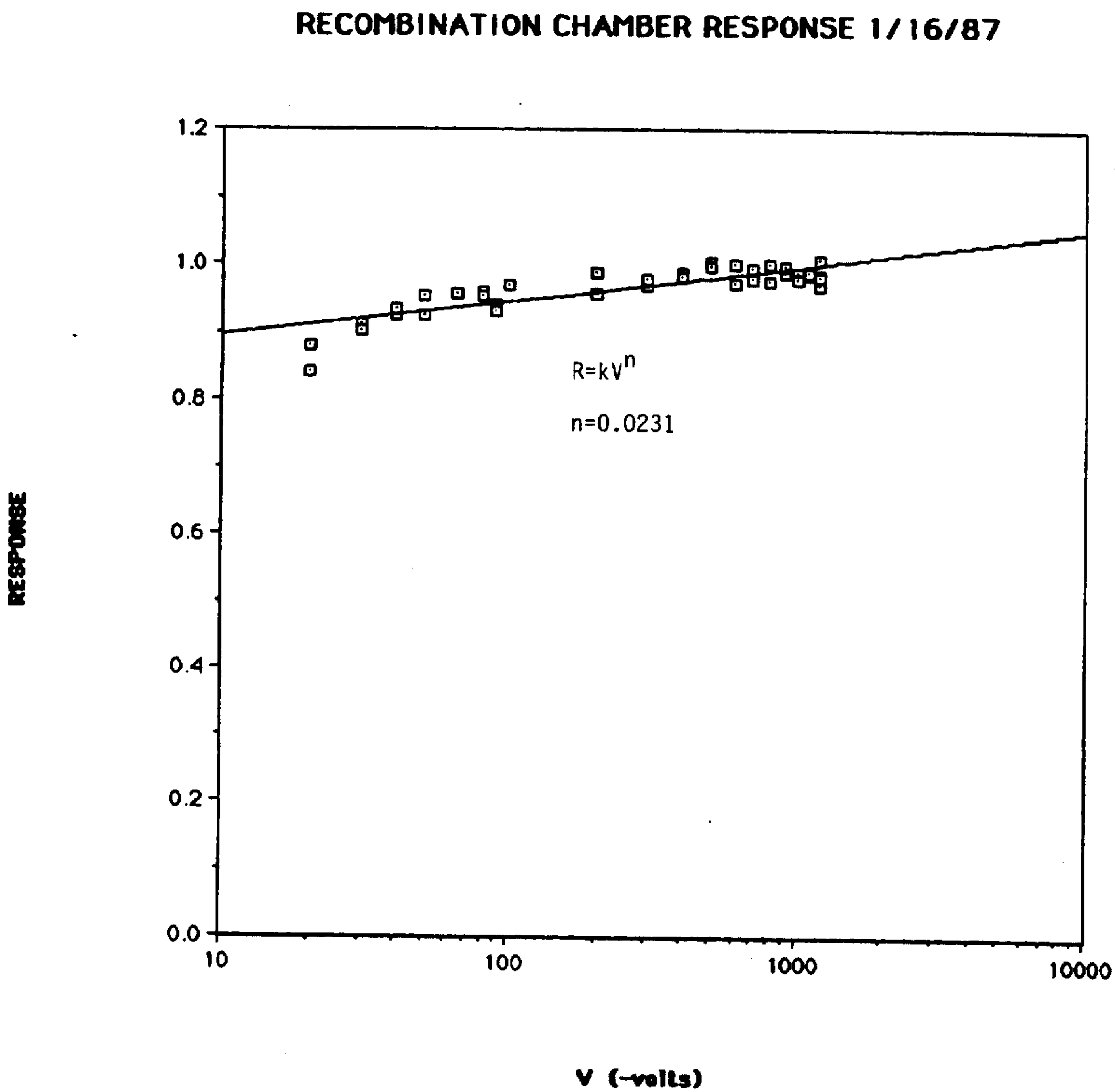



FIG 2



RECOMBINATION CHAMBER RESPONSE 1/16/87
RESPONSE
1.2
1.0
0.8
0.6
0.4
0.2
0.0
10
100
1000
10000
$R=kV^n$
n=0.0231
V (-volts)


FIG 3

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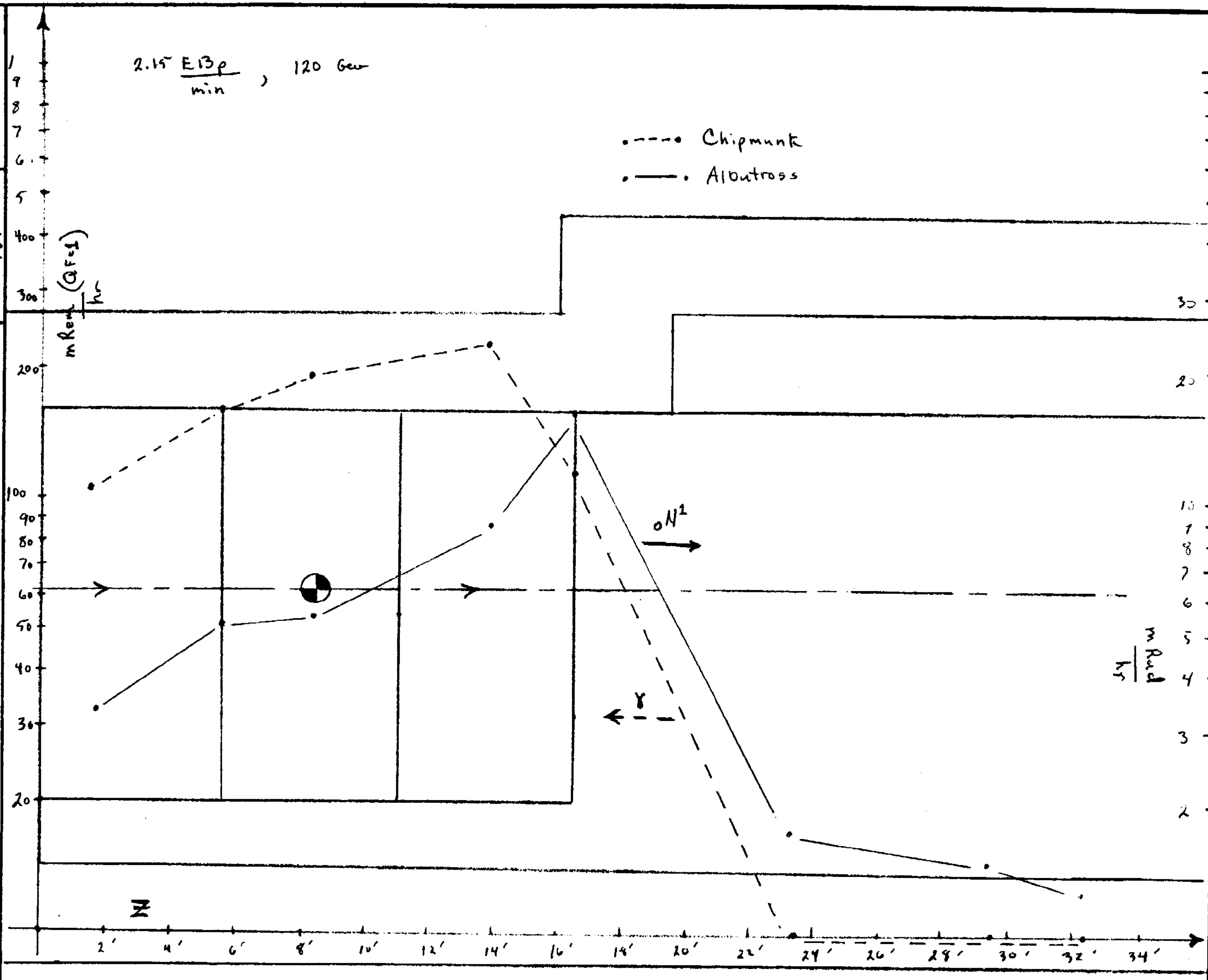


FIG 4